METZGER

Design for a Bridge Shop

Civil Engineering

B. S.

1905

DESIGN

FOR A

BRIDGE SHOP

BY

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THESIS

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This is to certify that the thesis prepared under the immediate supervision of Instructor C. W. Malcolm by

LOUIS CHARLES FREDERICK METZGER

entitled DESIGN FOR A BRIDGE SHOP

is approved by me as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering

Ira O. Baker.

Head of Department of Civil Engineering

DESIGN
FOR A
HIGHWAY-BRIDGE SHOP

INTRODUCTION

During the rapid development of this country, many temporary structures were built which, as the community grows in numbers and in wealth, are being replaced by permanent or semi-permanent structures. This is notably true of highway bridges; and has led to the establishment of many shops for the manufacture of bridges and other steel-framed structures. The business of some of these shops has grown so rapidly that at first additions were necessary; then, for the economic handling of the

bridge work, it became imperative to build shops for bridge work alone.

The design of such a shop will be the subject of this thesis. Although the placing of the necessary machinery will be indicated only approximately on the plan, it must be considered in the design of the building, together with the necessary hoists or lifts which form an indispensable part of the equipment of a manufacturing plant.

DATA

The first question the designer asks is: "How big shall the shop be?" or "How much of an investment is to be made"?

The latter depends on what volume of business the party expects to do and how much capital he will risk in his venture. There are other con-

ditions which need not be enumerated here.

The first question is partly answered by the answer to the second; but it also depends on the economic conditions of that part of the country where it is intended to locate the shop. Further, it depends on the executive ability of the manager, so that, for a given investment, he gets satisfactory monetary returns.

When it has been decided how much of an output the shop is to be designed for, the number and size of the necessary machines will determine the floor space to be provided. If these are not considered with their due weight, the shop may not be efficient; in other words, it may not be possible to get satisfactory returns from the

investment. A judicious proportioning and arrangement of the several parts results in the advantageous handling of the product during its manufacture.

The writer visited several shops to learn some of the methods of working, to find out how large a floor space is required for a certain output, and to get general information about bridge shops. Of the shops visited only one was modern, one was made up of additions to old buildings which had been built for other purposes and another was closed for remodeling. The first, alone, furnished definite data, although the others led to deductions which substantiate the judgment used in building the above mentioned modern shop.

DESIGN

It has been decided that the shop may be expected to have an output of about one hundred and seventy-five tons per month. From data collected it was determined that a building to house the whole shop and also include the office ought to cover an area of seventy by one hundred and sixty feet.

Since, in a shop, unobstructed floor space is valuable for the advantageous handling of material and also for superintending the work carried on, the roof truss will be made strong enough to carry a load of five tons supported at any point of the lower chord. Ordinarily one piece of a highway bridge will not exceed three tons in weight.

It has been considered advisable to design for a larger

wind load than would ordinarily be provided for in any other building. This was done for the following reason: The building is to house the machinery which is used to prepare materials for bridges, and, after a destructive storm, may also be called upon to furnish prepared materials for other structures. At such a time it might be very detrimental to permit a competitor to get the work in the vicinity while the bridge shop is temporarily disabled.

In the truss $\frac{3}{4}''$ rivets will be used, while in the intermediate columns $\frac{7}{8}''$ rivets will be used to take the shear.

For further data see Plates I, II, and III.

The stresses for which the truss is designed are shown on the stress sheet (Plate I), and a table of stresses

is given on the pages following this plate.

Max. is the abbreviation for Maximum; Con. for Concentrated. The other words in the column headings are selfexplanatory, except that Point I, II, and III refer to points indicated on the stress sheet.

Since A-16 (see Plate I) is very long and supported at its middle it may be made of a lighter section than would otherwise be required. This hanger will not effect any of the maximum stresses in the members of the truss, thus making a recalculation of stresses unnecessary. The lower chord will have the same section throughout, and will be spliced at the center.

The comparatively shallow depth of the intermediate posts (12") with the consequent larger amount

of metal is warranted by the saving of floor space. In some members of the truss there is more metal than is required by the stresses. This is justified on the grounds of appearance and avoidance of the use of many different sizes of sections.

In the design the specifications given in Ketchum's book on "Steel Mill Buildings" were followed, and for properties of sections Cambria's hand book was consulted.

The intermediate columns are anchored by one-inch upset bolts. See Plate III for column foundation and footing plan. For corner posts 6"x6"x½" angles will be used. Since they are practically fixed by the girts, no large transverse stress can come upon them. They are held in place by one ¾" anchor bolt which passes through a bent plate that in turn is fast-

ened to the angle by four 3/4" rivets. The corner post will rest on a plate 10"×3/4"×10" which forms the top of a 13"×13" pier, this pier having a depth of five feet. The piers and column foundations are of concrete mixed in proportion of one of cement, three of clean sharp sand and five of broken stone. The anchor bolts for the corner posts will extend into the pier two feet, and there be fastened to a cast iron washer. This washer is 4"×3/4"×4". For posts in the end of the building 10 inch by 25 lbs. I beams are used. These posts have a 3"×3"×3/8" angle riveted to each side of the web by which they are anchored to the 13"×13" pier. The angles are riveted to the foot of the posts by two 3/4" rivets, and a 3/4" bolt in each angle fastens the post to the pier. This connec-

tion is the same as is used for the corner posts.

At the same height as the lower chord of the trusses a 12 in. by 20.5 lbs. channel is riveted to the inside of the posts in the end of the shop

For the eave struts 10 in. by 15 lbs channels are used

For purlins and girts 7 in. by 9¾ lbs. channels are used.

The diagonal rods for wind bracing are 1 in. in diameter and upset to 1¼ in.. They have clevises at each end to connect, by a pin, to the upper edge of lower chord of the truss and to the channel on the end posts. For the wind bracing strut, see Plate II. The diagonals for wind bracing of walls are also 1 in. upset rods.

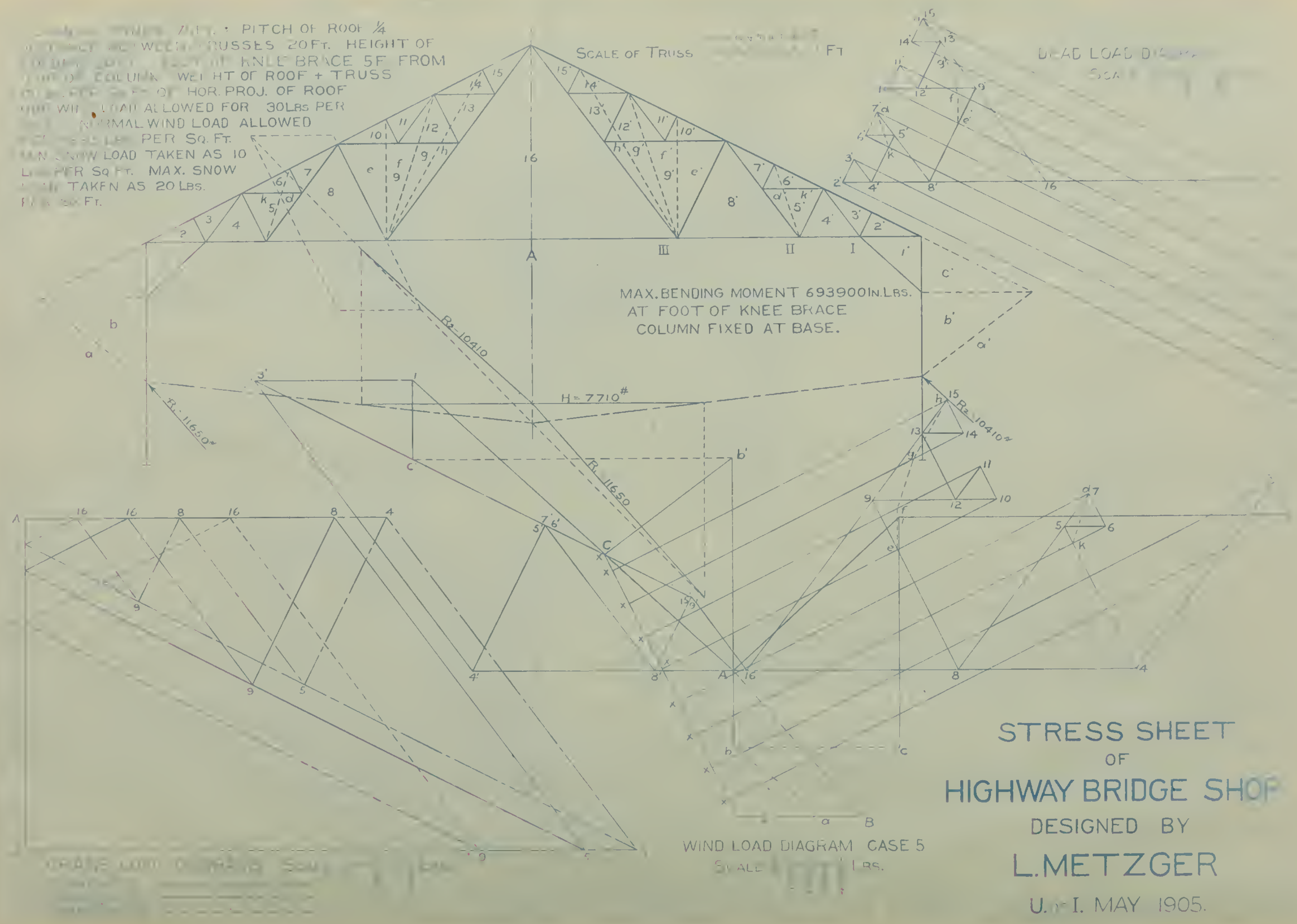
For the roof No. 18 corrugated steel is used and the walls of the

shop are covered with No. 20 corrugated steel.

Under the roof covering an anti-condensation lining is applied. This lining is placed as follows: Poultry netting is fastened to one eave purlin, passed over the ridge, stretched tight and fastened to the other eave purlin. The edges of the wire are woven together and the netting is fastened to each purlin. A layer of asbestos paper 1/16 in. thick is laid on the netting and two layers of tar paper are laid over all. The corrugated steel is then fastened in the usual way.

For ventilation, four Star Ventilators are placed on the ridge of the roof.

Plate I



STRESS SHEET
OF
HIGHWAY BRIDGE SHOP
DESIGNED BY
L. METZGER
U. of I. MAY 1905.

MEMBER	DEAD & MIN. SNOW LOAD	MAX. SNOW LOAD	WIND LOAD CASE 5	WIND + DEAD LOAD	LOAD AT I ON LOWER CHORD	LOAD AT II ON LOWER CHORD	LOAD AT III ON LOWER CHORD	MAX. CON. LOAD	WIND + DEAD + CON. LOAD	MAX. SNOW + DEAD + CON. LOAD	MAXIMUM
R_1	+7000	+14000	+11650		+ 780	+ 1570	+ 3150	+ 3150		+24150	+24150
R_2	+7000	+14000	+10410		+ 9220	+ 8430	+ 6850	+ 9220		+30220	+30220
bA	+7000	+14000	+ 4620	+11620	+ 780	+ 1570	+ 3150	+ 3150	+14770	+24150	+24150
b'A'	+7000	+14000	+12700	+19700	+ 9220	+ 8430	+ 6850	+ 9220	+28920	+30220	+30220
c1	+7000	+14000	+13750	+20750	+ 780	+ 1570	+ 3150	+ 3150	+29970	+24150	+30220
c'1'	+7000	+14000	− 4750	+ 2250	+ 9220	+ 8430	+ 6850	+ 9220	+ 5400	+30220	
1A	—	—	−13500	−13500	—	—	—	—	−13500	—	−13500
1'A'	—	—	+25920	+25920	—	—	—	—	+25920	—	+25920
2-1	−13110	−26220	−23420	−36530	− 1560	− 3150	− 6240	− 6240	−55030	−45570	−57830
2'-1'	−13110	−26220	+ 9590	− 3520	−18500	−16920	−13730	−18500	− 9760	−57830	
3-2	+ 780	+ 1560	+ 2200	+ 2980	—	—	—	—	+ 2980	+ 2340	+ 2980
3'-2'	+ 780	+ 1560	—	+ 780	—	—	—	—	+ 780	+ 2340	
4-3	− 860	− 1720	−13850	−14710	—	—	—	—	−27210	− 2580	−27210
4'-3'	− 860	− 1720	+21850	+20990	−12500	—	—	−12500	+20990	−15080	+20990
5-4	+ 1560	+ 3120	+ 9500	+11060	—	—	—	—	+16670	+ 4680	+11060
5'-4'	+ 1560	+ 3120	− 9780	− 8220	+ 5610	—	—	+ 5610	− 8220	+10290	− 8220
6-5	− 860	− 1720	− 2480	− 3340	—	—	—	—	− 3340	− 2580	− 3340
6'-5'	− 860	− 1720	—	− 860	—	—	—	—	− 860	− 2580	
7-6	+ 780	+ 1560	+ 2200	+ 2980	—	—	—	—	+ 2980	+ 2340	+ 2980
7'-6'	+ 780	+ 1560	—	+ 780	—	—	—	—	+ 780	+ 2340	
8-5	− 1750	− 3500	−10620	−12370	—	—	—	—	−24870	− 5220	−24870
8'-5'	− 1750	− 3500	+10920	+ 9170	− 6280	−12500	—	−12500	+ 9170	−17750	+ 9170
8-7	− 2610	− 5220	−13100	−15710	—	—	—	—	−28210	− 7830	−28210
8'-7'	− 2610	− 5220	+10920	+ 8370	− 6280	−12500	—	−12500	+ 8310	−20330	+ 8310

MEMBER	DEAD & MIN. SNOW LOAD	MAX. SNOW LOAD	WIND LOAD CASE 5	WIND + DEAD LOAD	LOAD AT I ON LOWER CHORD	LOAD AT II ON LOWER CHORD	LOAD AT III ON LOWER CHORD	MAX. CON. LOAD	WIND + DEAD + CON. LOAD	MAX. SNOW + DEAD + CON. LOAD	MAXIMUM
9-8	+ 3120	+ 6240	+11300	+14420	—	—	—	—	+20030	+ 9360	+20030
9'-8'	+ 3120	+ 6240	− 4900	− 1780	+ 2810	+ 5610	—	+ 5610	− 1780	+14970	− 1780
9-16	− 3490	− 7980	−12620	−17110	—	—	—	—	−29600	−10470	−29600
9'-16'	− 3490	− 7980	+ 5460	+ 1970	− 3150	− 6280	−12490	−12490	+ 1970	−22960	+ 1970
10-9	− 2610	− 5220	− 7430	−10040	—	—	—	—	−10040	− 7830	−10040
10'-9'	− 2610	− 5220	—	− 2610	—	—	—	—	− 2610	− 7830	
11-10	+ 780	+ 1560	+ 2200	+ 2980	—	—	—	—	+ 2980	+ 2340	+ 2980
11'-10'	+ 780	+ 1560	—	+ 780	—	—	—	—	+ 780	+ 2340	
12-9	− 1730	− 3460	− 4950	− 6680	—	—	—	—	− 6680	− 5190	− 6680
12'-9'	− 1730	− 3460	—	− 1730	—	—	—	—	− 1730	− 5190	
12-11	− 860	− 1720	− 2480	− 3340	—	—	—	—	− 3340	− 2580	− 3340
12'-11'	− 860	− 1720	—	− 860	—	—	—	—	− 860	− 2580	
12-13	+ 1560	+ 3120	+ 4400	+ 5960	—	—	—	—	+ 5960	+ 4680	+ 5960
12'-13'	+ 1560	+ 3120	—	+ 1560	—	—	—	—	+ 1560	+ 4680	
13-14	− 860	− 1720	− 2480	− 3340	—	—	—	—	− 3340	− 2580	− 3340
13'-14'	− 860	− 1720	—	− 860	—	—	—	—	− 860	− 2580	
13-16	− 5220	−10440	−17600	−22820	—	—	—	—	−35310	−15660	−35310
13'-16'	− 5220	−10440	+ 5460	+ 240	− 3150	− 6280	−12490	−12490	+ 240	−28140	+ 240
14-15	+ 780	+ 1560	+ 2200	+ 2980	—	—	—	—	+ 2980	+ 2340	+ 2980
14'-15'	+ 780	+ 1560	—	+ 780	—	—	—	—	+ 780	+ 2340	
15-16	− 6100	−12200	−20050	−26150	—	—	—	—	−38640	−18300	−38640
15'-16'	− 6100	−12200	+ 5460	+ 540	− 3150	− 6280	−12490	−12490	+ 540	−30790	+ 540
15-X	+11940	+23880	+22400	+34340	+ 1770	+ 3520	+ 7000	+ 7000	+49680	+42720	+51060
15'-X'	+11940	+23880	+ 5800	+17740	+ 3880	+ 7720	+15340	+15340	+24740	+51060	

MEMBER	DEAD & MIN. SNOW LOAD	MAX. SNOW LOAD	WIND LOAD CASE 5	WIND + DEAD LOAD	LOAD AT I ON LOWER CHORD	LOAD AT II ON LOWER CHORD	LOAD AT III ON LOWER CHORD	MAX. CON. LOAD	WIND + DEAD + CON. LOAD	MAX. SNOW + DEAD + CON. LOAD	MAXIMUM.
14-X	+12330	+24660	+22400	+34730	+ 1770	+ 3520	+ 7000	+ 7000	+ 50070	+43990	+52330
14'-X'	+12330	+24660	+ 5800	+18130	+ 3880	+ 7720	+15340	+15340	+ 25130	+52330	
11-X	+12720	+25440	+22400	+35120	+ 1770	+ 3520	+ 7000	+ 7000	+50460	+45160	+53500
11'-X'	+12720	+25440	+ 5800	+18520	+ 3880	+ 7720	+15340	+15340	+25520	+53500	
10-X	+13110	+26220	+22400	+35510	+ 1770	+ 3520	+ 7000	+ 7000	+50850	+46330	+54670
10'-X'	+13110	+26220	+ 5800	+18910	+ 3880	+ 7720	+15340	+15340	+25910	+54670	
7-X	+13500	+27000	+27500	+41000	+ 1770	+ 3520	+ 7000	+ 7000	+59900	+47500	+59900
7'-X'	+13500	+27000	- 4000	+ 9500	+ 9490	+18900	+15340	+18900	+ 16500	+59500	
6-X	+13890	+27780	+27500	+41390	+ 1770	+ 3520	+ 7000	+ 7000	+59390	+48670	+60670
6'-X'	+13890	+27780	- 4000	+ 9890	+ 9490	+18900	+15340	+18900	+16890	+60670	
3-X	+14280	+28560	+37650	+51930	+ 1770	+ 3520	+ 7000	+ 7000	+72600	+49840	+72600
3'-X'	+14280	+28560	-23500	- 9220	+20670	+18900	+15340	+20670	- 2220	+63510	- 9220
2-X	+14670	+29340	+37650	+52320	+ 1770	+ 3520	+ 7000	+ 7000	+72990	+ 64680	+72990
2'-X'	+14670	+29340	-23500	- 8830	+20670	+18900	+15340	+20670	- 1830	+51010	- 8830
A-4	-12260	-24520	+24100	-36360	- 1560	- 3150	- 6240	- 6240	-53280	-43020	-53700
A'-4'	-12260	-24520	+15600	+ 3340	-10990	-16920	-13730	-16920	- 2900	-53700	+ 3340
A-8	-10510	-21020	-13450	-23960	- 1560	- 3150	- 6240	- 6240	-27690	-37770	-45260
A'-8'	-10510	-21020	+ 4690	- 5820	- 4710	- 9410	-13730	-13730	-12060	-45260	
A-16	- 7030	-14060	- 800	- 7830	- 1560	- 3150	- 6240	- 6240	-14070	-27330	-27330

Plate II

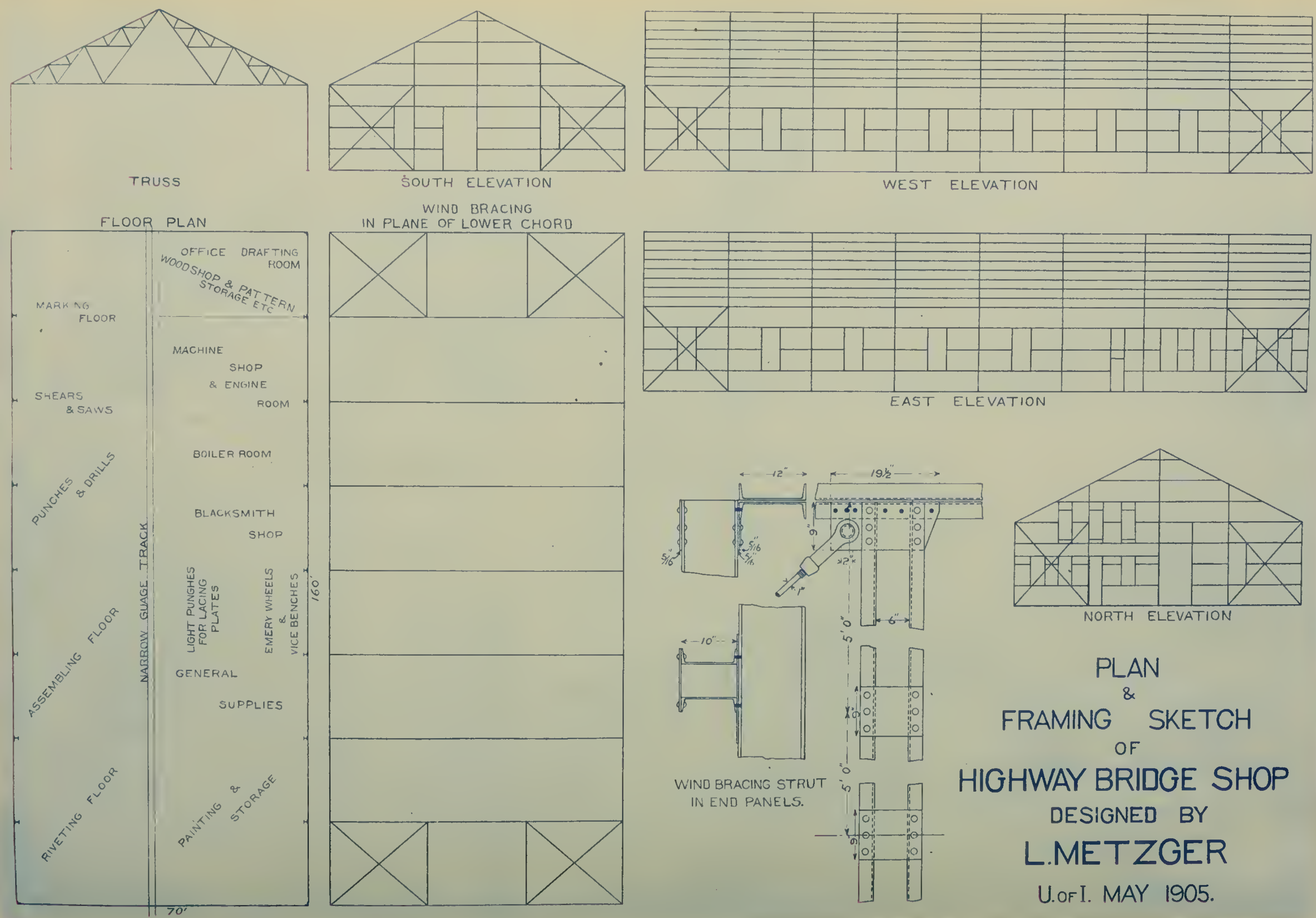
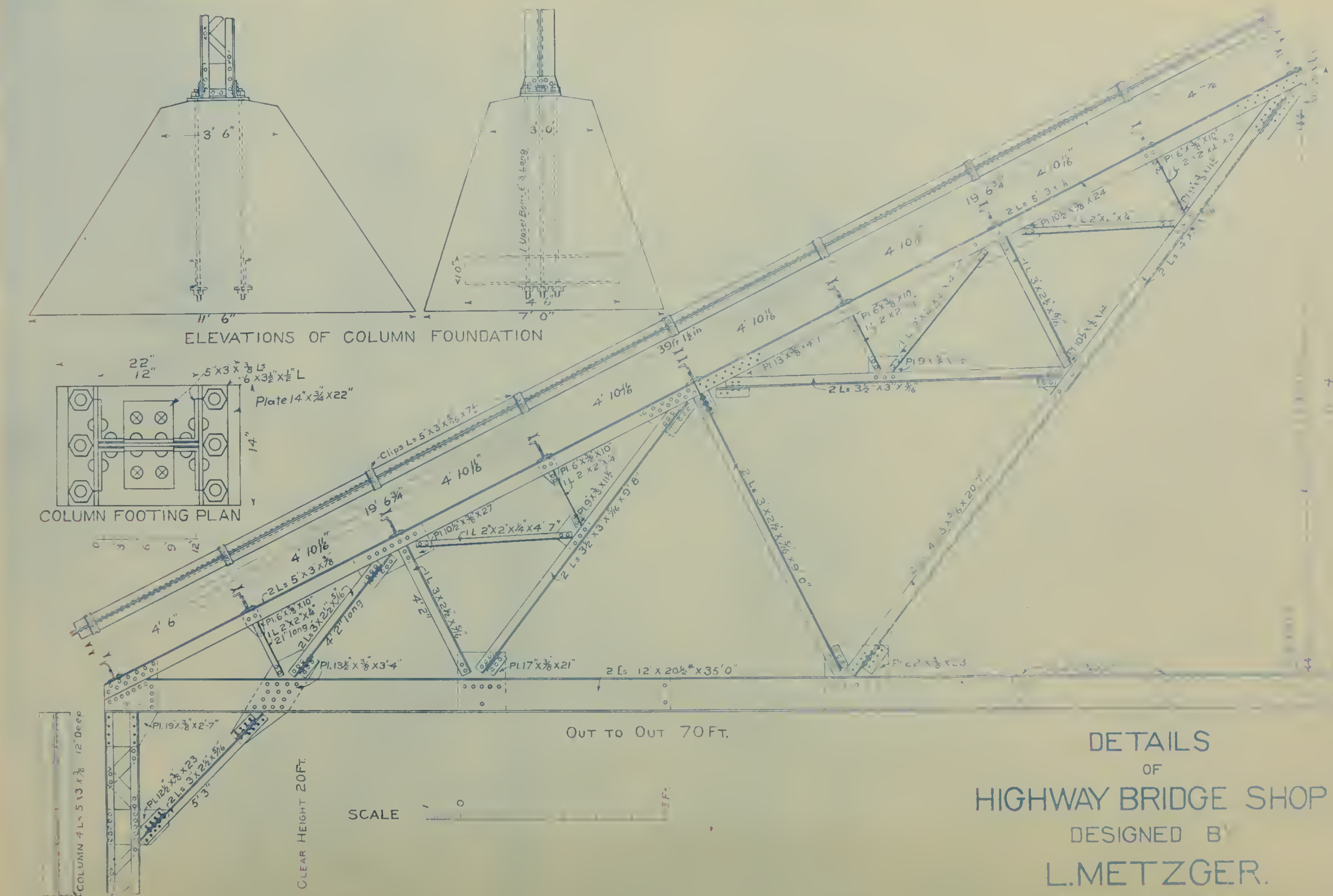

TRUSS
SOUTH ELEVATION
WEST ELEVATION
FLOOR PLAN
WIND BRACING
IN PLANE OF LOWER CHORD
OFFICE DRAFTING ROOM
WOODSHOP & PATTERN STORAGE ETC
MARKING FLOOR
MACHINE SHOP & ENGINE ROOM
SHEARS & SAWS
BOILER ROOM
PUNCHES & DRILLS
BLACKSMITH SHOP
NARROW GUAGE TRACK
LIGHT PUNCHES FOR LACING PLATES
EMERY WHEELS & VICE BENCHES
160'
ASSEMBLING FLOOR
GENERAL
SUPPLIES
RIVETING FLOOR
PAINTING & STORAGE
70'
EAST ELEVATION
12"
19½"
5/16
9"
2"
1"
6"
10"
5' 0"
5' 0"
9"
9"
WIND BRACING STRUT
IN END PANELS.
NORTH ELEVATION
PLAN
&
FRAMING SKETCH
OF
HIGHWAY BRIDGE SHOP
DESIGNED BY
L.METZGER
U.of I. MAY 1905.

Plate III



DETAILS

OF

HIGHWAY BRIDGE SHOP

DESIGNED BY

L. METZGER.

MAY 1905